High Temperature Oxidation Resistant Coatings Integrated with Carbon/Carbon Hot Structures, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

The development of new hypersonic capabilities is important for the United States. In the near-term, application of hypersonic research and technologies is likely to be on enhanced defense systems, but this could eventually expand to include improved access to space capabilities that would directly benefit NASA. Hypersonic vehicle nose tips and leading edges require high thermal shock resistance combined with bending strength at a high angle of attack. Due to their high specific modulus, high fracture toughness and thermal conductivity, good thermal shock resistance, and excellent high temperature strength, advanced carbon/carbon (C/C) composites are considered as structural materials for atmospheric entry vehicles. C/C composites have densities in the range 1.6–2.0 gm/cm^3, much lower than those of metals and ceramics, and can significantly reduce hypersonic vehicle component weight. During reentry into the atmosphere, a vehicle nose tip and leading edges can encounter extreme convective and radiative heating loads with the very high temperatures. Unfortunately, C/C composites start to rapidly oxidize above 700° which restricts their engineering applications in air. Multiple concepts of oxidation resistant coatings are currently in development for carbon/carbon composite protection. Most of the coatings are based on silicon carbide in combination with different refractory compounds. Thermal analyses indicate that portions of the C/C horizontal control surface and nose leading edge of the Mach 10 vehicle will experience temperatures apprmissiles, missile defense interceptors.oaching 2200°C, exceeding even the single use temperature limit of the SiC coated carbon/carbon. An oxidation protection system is proposed for C/C hot structures that is SiC free and able to meet these high temperature requirements by using oxygen barrier and refractory oxide coatings.

Anticipated Benefits

Hypersonic vehicles, access to space, heat shields, crew capsules, boost engine exit cones, altitude control engine nozzles, roll control engine nozzles, re-entry aeroshells.

Hypersonic vehicles, access to space, heat shields, commercial crew capsules, rocket exit cones, altitude control engine nozzles, roll control engine nozzles, re-entry bodies, missiles, missile defense interceptors.

C/C Leading Edge with Iridium/Oxide Coating after Arc Jet testing at AEDC

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Small Business Innovation Research/Small Business Tech Transfer

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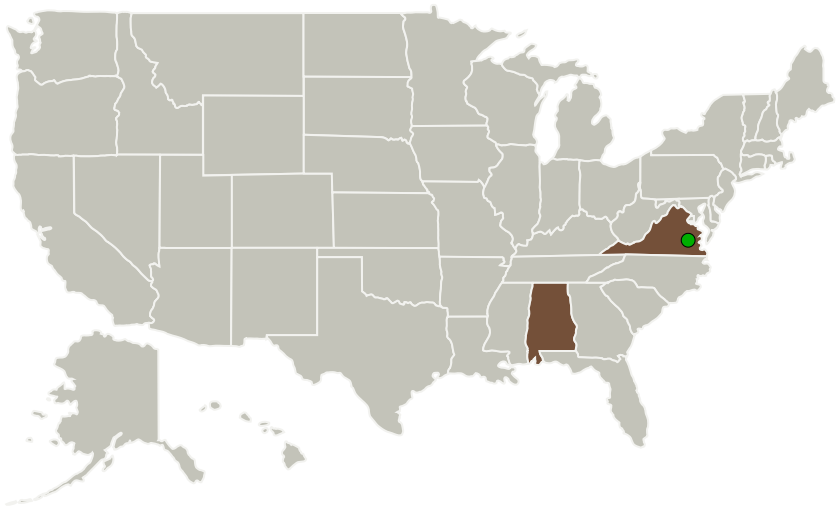
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
Alabama	Virginia

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141356)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

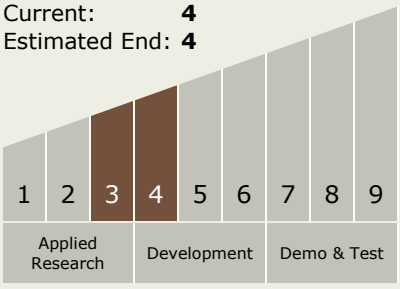
Carlos Torrez

Principal Investigator:

Anatoliy Shchetkovskiy

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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Images

Briefing Chart Image
High Temperature Oxidation Resistant Coatings Integrated with Carbon/Carbon Hot Structures, Phase I
(https://techport.nasa.gov/image/131923)

Final Summary Chart Image
High Temperature Oxidation Resistant Coatings Integrated with Carbon/Carbon Hot Structures, Phase I
(https://techport.nasa.gov/image/128626)

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.4 Materials for Extreme Environments

Target Destinations

Mars, Earth, Others Inside the Solar System